SRSTI 29.01.45 https://doi.org/10.52081/mpimet.2025.v11.i3.059

MAIN METHODS OF AUTOMATED THESAURUS IN THE EDUCATIONAL PROCESS

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Abstract. The extensive development of modern educational methods and scientific thinking has led to the study of innovative processes and the creation of new automated information retrieval systems.The implementation of new computer technologies allows the use of conventional information retrieval systems in the subject area for educational and informational activities, which can be described by a hierarchical dictionary – a thesaurus. This article presents one of the innovative methodological directions in the field of education: the process of automated reconstruction of a specific thesaurus. The creation of educational and informational materials, which involves searching and processing large volumes of information, is linked to the growth and improvement of modern information methods of learning. An important and necessary condition for the implementation of these methods is the preparation and creation of innovative projects and educational information retrieval programs. The extensive development of teaching methods in this scientific direction leads to the study of innovative processes and the creation of new automated information retrieval systems. To obtain effective solutions and impressive results from these studies, new computer technologies enable the use of conventional information retrieval systems for named searches of scientific and technical information. Any subject area of educational and informational activities can be described by a hierarchical dictionary of concepts in that area – a thesaurus. Furthermore, for most subject areas, such thesauruses have long been compiled.

Keywords: innovative process, information retrieval system, thesaurus, hierarchical dictionary, descriptors.

Introduction. The introduction of new directions by the European Union in education and the development of modern education, the increase in the number of large-scale complex projects located across various territories, and the need for appropriate relationships in their implementation at multiple levels of innovation in educational activities significantly enhances the role of systems for educational and informational support in the processes of training and creation of innovative projects and programs [1].

A thesaurus is a tree of concepts for a given subject area, starting with the most general concepts at the top and ending with the most specific and narrow ones at the bottom. Words (terms) in a thesaurus are typically related by "general-specific," "whole-part," and similar relationships.

In a broader sense, a thesaurus is interpreted as a description of a system of knowledge about reality, which is possessed by an individual information carrier or a group of carriers. This carrier may function as a receiver of additional information, resulting in changes to its thesaurus. The original thesaurus, in turn, defines the receiver's ability to process and receive semantic information.

The term "thesaurus" is widely used in computer science as a component of information retrieval systems.

An information retrieval thesaurus is a dictionary of terms and phrases, compiled according to specific rules, for a particular subject area, created to improve the quality of information retrieval within that field [2-3].

E-learning has become an integral part of modern education globally. In terms of e-learning adoption, Kazakhstan lags behind global leaders in this field (the United States, Finland, Singapore, South Korea, Canada, Australia, and New Zealand) by several years. At the same time, the educational models created by these countries, which are also economic leaders, are successfully working to achieve the strategic goal of increasing the country's competitiveness.

The introduction of information technologies based on the advantages of electronic computing technology at all stages plays a huge role in increasing the effectiveness of education.

The development of technology has contributed to the emergence of fundamentally new methods of information processing, a qualitatively new method of understanding the world, the creation of new ways of recording information and new forms of documents, changes in the format of documents and the possibilities for their storage, accounting and distribution. With the advent and development of electronic computing technology, computers, and digital information technologies, a special group of documents has emerged—electronic digital documents, the recording method of which is based on the principle of converting information into encoded digital form. The simplest form of representation for electronic digital documents is the file form. A file serves as a carrier of digital documented information during its creation, storage, use, and transmission over telecommunications channels, serving as a kind of "electronic paper" for an electronic document.

Technical devices act as intermediaries in informational communication between people, allowing them to obtain information inaccessible to direct human perception, quickly process huge amounts of data, transmit information over long distances, and preserve it for future generations. When talking about automated work with information using any technical devices, what is primarily meant is not the content of the information, but the form of its presentation.

In connection with these trends, the problem of creating high-quality electronic textbooks, manuals, laboratory practical training, reference books, etc. based on modern computer technologies is becoming increasingly urgent. Hypertext and multimedia tools (graphics, animation, audio, and video) allow for the presentation of educational material in an interactive and visual format, ensuring the rapid retrieval of necessary information. Computer-based training and assessment enhance the learning process and provide a rapid assessment of students' mastery of the educational material.

The Concept of the e-Learning System for 2018-2013 states that “The Ministry is taking measures to create educational resources in the form of electronic textbooks and multimedia educational programs. However, the created electronic textbooks, manuals and programs are distributed on CD and DVD media, are not web-oriented and are not intended for sharing and multiple use via the Internet.

When creating e-learning courses, developers must consider the requirement to support international standards to ensure compatibility based on SCORM, the de facto standard for e-learning systems. However, compliance with educational standards for Kazakhstani e-learning developments is currently only a recommendation..

In 2018, Azerbaijan approved the Rules for the Preparation, Review, and Publication of Textbooks, Teaching Aids, and Manuals. However, lists of approved educational materials, including electronic textbooks, are not published online and, therefore, are not accessible to potential users of educational resources.

A separate issue is the development and promotion of teachers' original electronic developments. Currently, there are no uniform requirements for the procedures for distributing such resources, and there are no effective mechanisms for motivating and incentivizing teachers who develop electronic educational materials. There are no rankings of the best developments.

An important condition for the functioning of the e-learning system is to ensure transparency and openness of the educational process, in accordance with the requirements of the best international practices and the need to position Azerbaijani education in international rankings. TIMSS, PISA, carried out by the International Associations for the Evaluation of Educational Achievement.

The Azerbaijani educational environment is represented online by websites of educational organizations, regional education departments, and subordinate agencies of the Ministry. Catalogs of electronic educational resources are published online only on the websites of their developers. There are no unified catalogues of educational websites in Azerbaijan, which hinders the wide dissemination of information in the field of education, on the informatization of education, and the popularization of Azerbaijani educational resources.

A modern information educational environment should unite, taking into account the needs of all participants: structural divisions and subordinate organizations of the Ministry, regional Education Departments, heads and teachers of educational organizations, students, and their parents. A modern information educational environment should unite, taking into account the needs of all participants: structural divisions and subordinate organizations of the Ministry, regional Education Departments, heads and teachers of educational organizations, students, and their parents.

The e-learning system includes distance learning capabilities with the active use of network technologies, via a local network and the global Internet.

The open distance learning system Moodle (www.moodle.nci.kz) is available on the website of the National Center for Informatization, which contains a fully functional modular LMS (Learning Management System) environment and is standardized in accordance with international standards for educational technologies. However, due to insufficient access to the Internet among educational organizations and potential users, this system has not been widely used in Azerbaijan.

Thus, the use of an e-learning system will only be effective if it is integrated into real educational processes in interaction with all participants in these processes."

Materials and Methods of Research. In the field of application of information retrieval thesauruses, two main directions are distinguished: document indexing using specific rules that utilize the semantic meaning of the text, and the use of hierarchical, associative, and synonymous relationships when processing user search queries. In addition, semantic relationships between descriptors can be used for the classification and categorization of documents, creating a list of words related to the query, and solving some other information retrieval tasks. The following figure illustrates an example of the use of a thesaurus in an information retrieval system:

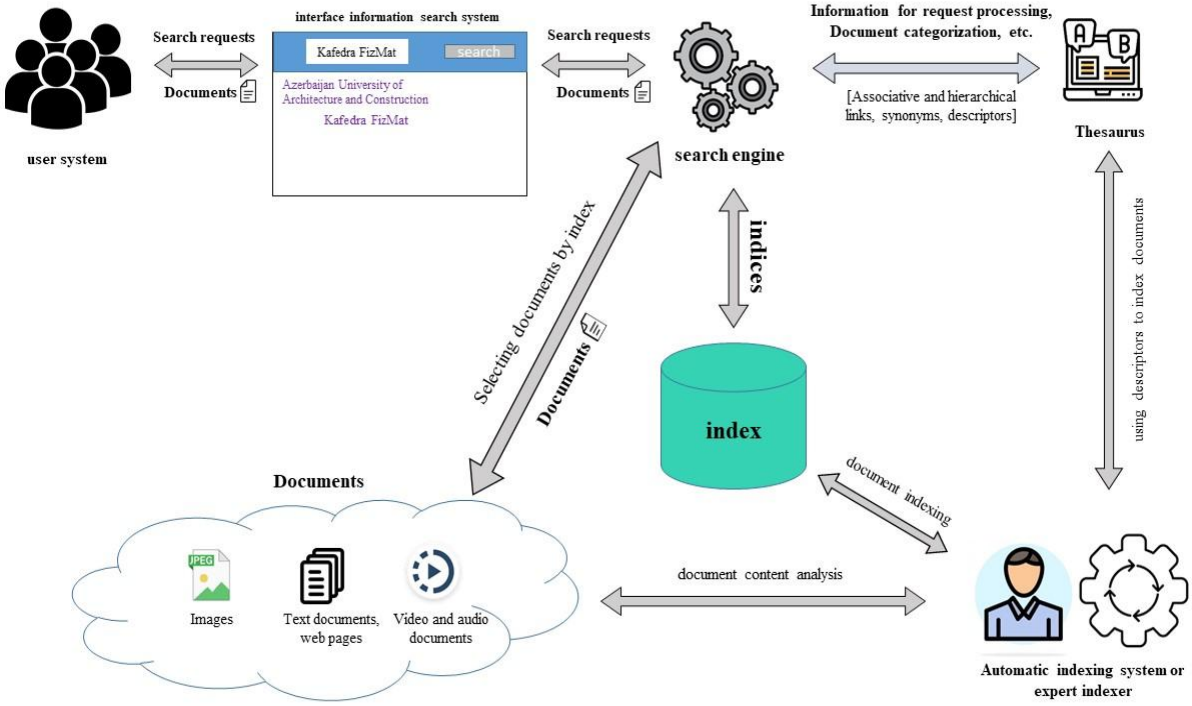


Figure 1- Example of Using a Thesaurus in an Information Retrieval System

A thesaurus consists of concepts, which typically contain one or more descriptors linked by a synonymy relationship. Descriptors are words and phrases that reflect the key concepts of the subject area. Concepts can be connected by associative, hierarchical, and other types of relationships [4-6].

Let's consider the process of automating the extraction of terms from a subject area within a text, given a thesaurus.

Suppose we are provided with a general thesaurus of the subject area. Then, all the terms that define the concepts of this thesaurus are represented as a set X_o, Y — represents the set of terms found in the text Z. Our task is to find:

$$F = X_o \cap Y \quad (1)$$

It is assumed that the original thesaurus is complete, i.e., the set of its terms should include all the terminological phrases used in the text. For the practical application of this method, it is sufficient for the majority of terms to be present in the thesaurus. The exact value of the term presence coefficient in the thesaurus relative to the total number of terms in the text cannot be determined, as currently, the classification or non-classification of a term as part of the subject area is an expert decision.

The problem of terminology extraction in natural language texts is one of the limitations imposed on the use of this method.

The greatest difficulty in the stage of extracting the terminology of a subject area from a text lies not in determining the intersection of sets but in defining the sets X_o and Y themselves.

While all terms of the thesaurus, being the terminological components of the thesaurus, should initially be isolated into a separate database when the thesaurus is created, the extraction of the set of terms from the text Z appears to be more problematic due to several features of the natural language description of the subject area. Natural language descriptions of any subject area are characterized by certain constructions used for text compression, such as coordinate terms, anaphoric constructions, and elliptical reductions [7-8]. An additional problem is homonymy. Some problems related to coordinate terms, anaphoric constructions, and elliptical reductions can be effectively solved by introducing a broad set of synonyms into the initial thesaurus. However, issues related to homonymy can only be effectively resolved through statistical analysis of the context surrounding the term suspected of being a homonym. A term can be assigned to a specific synonymous node in the thesaurus graph based on the highest number of matching terms found in the surrounding context, which corresponds to the nearest terms in the thesaurus suspected of homonymy. For these "nearest terms" in the thesaurus (i.e., with a proximity radius of 1), terms connected to the suspect term by any type of relationship are chosen. If this is not sufficient, one can expand both the segment of the text being analyzed, which contains the term suspected of homonymy, as well as the radius of the term’s surrounding context in the thesaurus.

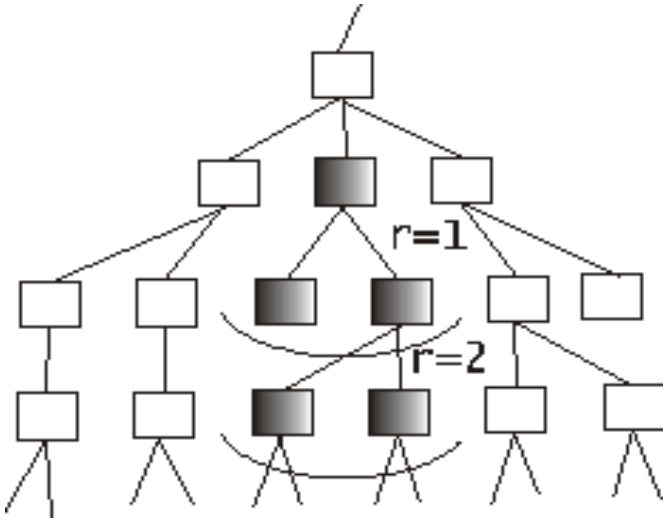


Figure 2 – Thesaurus Radius for a Term

Figure 2 illustrates the rules for extracting terms from a general thesaurus for analysis, with the goal of resolving homonymy. This method has been successfully applied in machine translation systems, with the difference being that for all possible meanings of homonyms, a separate list of possible surrounding words was created. The method's effectiveness reached up to 98%. In the case of using a semantic thesaurus, such a base for any term can be generated based on the thesaurus itself, using the method described above. However, statistical methods cannot fully overcome the difficulties of terminology extraction related to natural language reductions and homonymy. This limitation is one of the challenges when using the proposed techniques for automating hypertext design based on text using a semantic thesaurus. To address such problems, content analysis methods are typically used, which are effective but costly and time-consuming [9].

To construct a specific thesaurus, we introduce the concept of the matrix W_{So}. The rows and columns of this matrix correspond to the concepts s_i and s_j, and the elements of the matrix represent the presence or absence of a relationship R_k between them. W_{So} is built for each type of relationship in R.

$Wk_{ij}=1$ — if there is a relationship of type k between concepts s_i and s_j.

$Wk_{ij}=0$ — if there is no relationship of type k between concepts s_i and s_j.

The matrices of inverse relationships,

$$W_{P\text{-}E} = \hat{W}_{E\text{-}P}, \tag{2}$$

$$W_{S_0} = \bigcup_i^k W_{S_i} \tag{3}$$

Where k is the number of semantic relations, i.e., elements of the space R.

The union is performed by the logical OR operation over the elements of the relationship matrices.

Principle of forming relationship matrices for a specific thesaurus:

The order of the matrix W_{So} is determined by the dimensionality of the array S.

$$X_{i0} \cup X_{j\gamma} \neq \emptyset \tag{4}$$

if $S_{i0} = S_j$

and $S_{i0} = S_{k\gamma}$, *then* $r_i l_0 = r_j k_\gamma$

Thus, the elements of the relationship matrix for a specific thesaurus are defined based on the types of relationships. The value corresponding to the intersection of the row and column of the original matrix is taken as the element.

The specific thesaurus constructed in this way is a subset of the general one. It contains the terminology of the text and the thesaurus relationships between the terms in the text. The specific thesaurus, which has the structure of a graph, will form the basis of the relationship graph for the designed hypertext system [10-11].

Discussions and results. If at least one term from the general thesaurus of the given text is present, a specific thesaurus can be created for this text. However, not every specific thesaurus allows the automated establishment of a hypertext system in such a way that the principle of generalizability is also taken into account, since similar relationships maintain the connectedness property of the hypertext system graph, while semantic search based on them becomes more difficult. In this context, it is necessary to consider the limitations on using the method depending on the properties of the specific thesaurus.

There are various mathematical methods for checking graph connectivity, such as depth-first search in graphs, or multiplying the adjacency matrix by itself and analyzing the result. However, these methods are more complex to implement programmatically.

There is also the possibility of using a method for automated correction of a specific thesaurus.

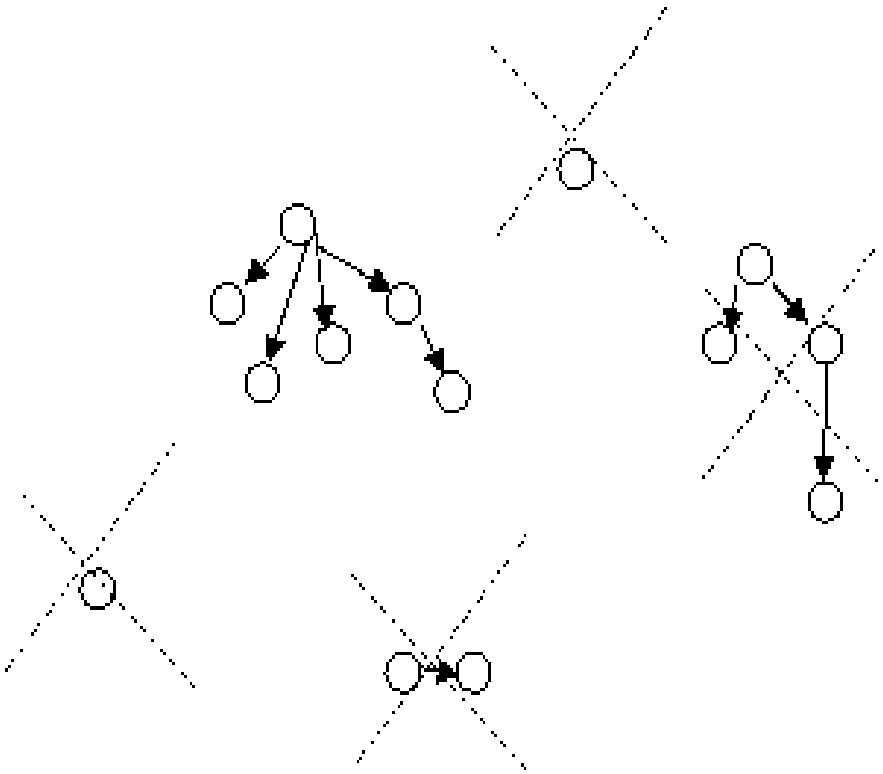
The correction method for the specific thesaurus is based on the following principles:

1. *Pruning disconnected subgraphs* involves selecting the connected component of the specific thesaurus with the largest number of nodes from all available components.

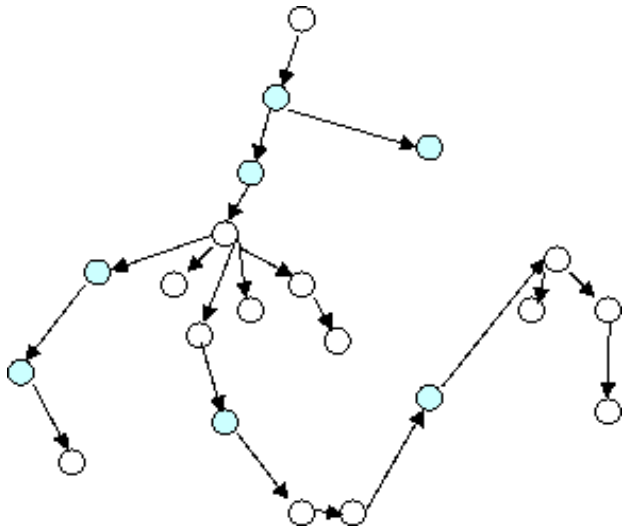
2. *Linking frames into a network* involves adding paths from the general thesaurus to the existing structure to ensure the system's connectedness and reconstructing missing paths by identifying vertices with no incoming hierarchical links and adding additional vertices and connections from the general thesaurus until the structure becomes fully connected. When reconstructing the linking paths, additional vertices from the general thesaurus are added to the specific thesaurus, along with connections between these vertices and the terms.

Reconstruction is performed from the "dangling" vertices strictly from bottom to top, until the upper vertex is either the last in the hierarchy of the general thesaurus or belongs to the specific thesaurus and is no longer dangling. Then, all vertices and arcs of the resulting connected structure are removed, starting from the only dangling vertex, following the direct hierarchical relationships until a vertex is encountered that has more than one lower term in the hierarchical relation. This vertex should be kept as the first in the hierarchy for the corrected specific thesaurus. Figure 3 illustrates the principles of using both methods [12-13].

It is also possible to combine the pruning and reconstruction methods using the general thesaurus to obtain a connected structure for the hierarchical thesaurus. Pruning should be applied to those connected components of the specific thesaurus whose connecting paths exceed the maximum allowable length. If the amount of terminology being pruned is significantly smaller than its total amount, it is advisable to construct a hypertext system based on such a specific thesaurus using the proposed method.



A. Bringing the specific thesaurus graph into a connected form using the pruning method



B. Bringing the specific thesaurus graph into a connected form using the reconstruction method based on the general thesaurus. The shaded nodes of the graph are restored using the general thesaurus

Figure 3 – Methods for correcting the specific thesaurus

The values of the maximum allowable path length connecting semantically distant subgraphs of the specific thesaurus and the coefficient ratio of the number of pruned nodes of the specific thesaurus to their total number $k_{omp} = \frac{N_{omp}}{n}$, are the criteria for the feasibility of constructing a hypertext system based on the thesaurus method for the textual material. The values of these coefficients can only be identified through the accumulation of experience in the practical use of this method, either by statistical analysis of these values or through expert assessments. Expert assessments of these values [14].

$$l_{cd} = 4,$$
$$k_{omp} = 0.1$$

.

Thus, the connectivity properties of the specific thesaurus graph, derived from the source text, allow conclusions to be drawn about the suitability of the text source for automating the construction of a hypertext system using the thesaurus method.

Conclusion. The implementation of modern automated thesaurus methods in the educational and informational process, covering all the terms of the subject area present in the original text and possessing some terminological redundancy, makes it possible to construct a hypertext system based on such a specific thesaurus, provided the principle of generalizability is followed. This is achievable under the condition that the general thesaurus graph is connected. In the degenerate case, the system can be constructed from the entire general thesaurus graph. However, for some frames of the system, there may be no informational articles. In such cases, the question should not be about the feasibility of automating the formation of the hypertext system, but about the advisability of using this method. A situation may arise where the number of connecting terms exceeds the number of terms in the specific thesaurus, making it obvious that building the system using this method is not practical. For example, this could happen if two or more semantically unrelated passages, or passages linked only by association, are submitted for analysis. In this case, the semantic proximity of the connected subgraphs should be considered, with the criterion for this proximity being the length of the minimum path in the general graph that connects the root vertices of the subgraphs [15].

The most optimal solution to determine the feasibility of constructing a hypertext system appears to be limiting the length of the connecting path to one or two nodes. If the connecting path is longer, the decision should be made that constructing the system using this method is impractical.

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БІЛІМ БЕРУ ПРОЦЕСІНДЕГІ АВТОМАТТАНДЫРЫЛҒАН ТЕЗАУРУСТЫҢ НЕГІЗГІ ӘДІСТЕРІ

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Аңдатпа. Ғылыми ойдың заманауи білім беру әдістерінің кең көлемде дамуы инновациялық процестерді зерттеуге және жаңа автоматтандырылған ақпараттық іздеу жүйелерін құруға әкеледі. Жаңа компьютерлік технологияларды енгізу білім беру және ақпараттық іс-әрекеттер үшін пәндік салада кәдімгі ақпараттық іздеу жүйелерін пайдалануға мүмкіндік береді, оны иерархиялық сөздік – тезаурус арқылы сипаттауға болады. Бұл мақалада білім беру саласындағы инновациялық оқу-әдістемелік бағыттардың бірі: нақты тезаурусты автоматтандырылған қайта құру процесі берілген. Ақпараттың үлкен көлемін іздеу мен өңдеуді көздейтін оқу-ақпараттық материалдарды құру заманауи ақпараттық оқыту әдістерінің өсуімен және жетілдірілуімен байланысты. Бұл әдістерді жүзеге асырудың маңызды және қажетті шарты инновациялық жобалар мен білім беру ақпараттық-іздестіру бағдарламаларын дайындау және құру болып табылады. Бұл ғылыми бағыттағы оқыту әдістерінің кең көлемде дамуы инновациялық процестерді зерттеуге және жаңа автоматтандырылған ақпараттық іздеу жүйелерін құруға әкеледі. Осы зерттеулерден тиімді шешімдер мен әсерлі нәтижелерді алу үшін жаңа компьютерлік технологиялар ғылыми-техникалық ақпаратты атаулы іздеу үшін кәдімгі ақпараттық іздеу жүйелерін пайдалануға мүмкіндік береді. Оқу-ақпараттық қызметтің кез келген

пәндік саласын сол саладағы ұғымдардың иерархиялық сөздігі – тезаурус арқылы сипаттауға болады. Сонымен қатар, көптеген пәндік салалар үшін мұндай тезаурустар бұрыннан жинақталған.

Тірек сөздер: инновациялық процесс, ақпараттық іздеу жүйесі, тезаурус, иерархиялық сөздік, дескрипторлар.

ОСНОВНЫЕ МЕТОДЫ АВТОМАТИЗИРОВАННОГО ТЕЗАУРУСА В УЧЕБНОМ ПРОЦЕССЕ

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Аннотация. Широкое развитие современных методов обучения научной мысли приводит к изучению инновационных процессов и созданию новых автоматизированных систем поиска информации. Внедрение новых компьютерных технологий позволяет использовать традиционные системы поиска информации в предметной области для учебно-информационной деятельности, которую можно описать иерархическим словарем – тезаурусом. В данной статье представлено одно из инновационных учебно-методических направлений в сфере образования: процесс автоматизированной реконструкции определенного тезауруса. Создание учебно-информационных материалов, подразумевающее поиск и обработку больших объемов информации, связано с развитием и совершенствованием современных информационных методов обучения. Важным и необходимым условием реализации этих методов является подготовка и создание инновационных проектов и образовательных программ поиска информации. Развитие методов обучения в этом научном направлении приводит к изучению инновационных процессов и созданию новых автоматизированных систем поиска информации. Для достижение эффективных решений и впечатляющих результатов в этих исследованиях новые компьютерные технологии позволяют использовать традиционные информационно-поисковые системы для целевого поиска научно-технической информации. Любая предметная область образовательной и информационной деятельности может быть описана иерархическим словарём концептов этой области – тезаурусом. Более того, для большинства предметных областей такие тезаурусы уже давно составлены.

Ключевые слова: инновационный процесс, информационно-поисковая система, тезаурус, иерархический словарь, дескрипторы.